# Methods for IEB Design

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Design Issues:

- *No single nationally accepted method for analysis and design of integral abutment bridges.*
- *AASHTO Standard Specifications for Highway Bridges 17th Edition does not address.*
- *AASHTO LRFD Bridge Design Specifications 3rd Ed., Art. 11.6.1.3, recommends following FHWA Technical Advisory T 5140.13 (1980).*
- *Not all states have approved the use of integral bridges.*
- *Active states have developed their own comfort envelope for when to use integral bridges.*

# Methods for IEB Design

Three Main Design Methodologies:

1. No Analysis of Lateral Effects.
2. Simplified Analysis of Lateral Effects.
3. Rigorous Analysis of Lateral Effects.

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# Methods for IEB Design

## 1. No Analysis of Lateral Effects.

- Design bridge using conventional approach and neglect any additional potential loading.
- $(DL_{TOTAL} + LL_{TOTAL})$ / Allowable Pile Load = # of Piles
- Lateral forces and movements are neglected.
- Some engineers use this approach when the bridge is within the DOT's established comfort envelope for length, skew, etc.
- Most often occurs when the DOT has a long history of using integral bridges and has standardized the detailing of the abutments.
- Incorporate the DOT's standard detailing practices at the abutments.

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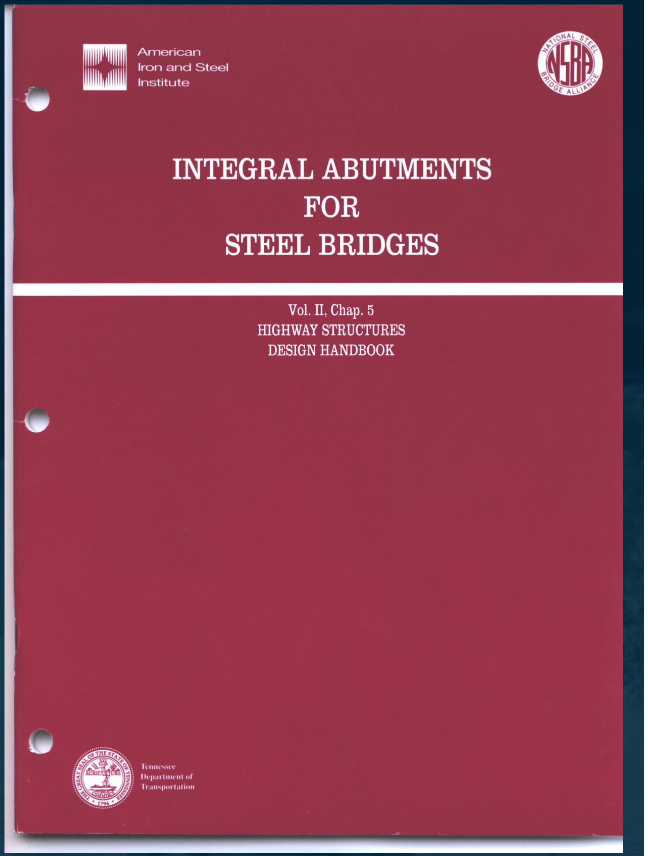
# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

General Approach:

- Models end bents independently from the bridge.
- Approach follows the method outlined by Wasserman, et al. (see reference no. 47 on provided list) which can be found in the AISI/NSBA Highway Structures Design Handbook, Volume II, Chapter 5.



# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

Determine Pile Loading:

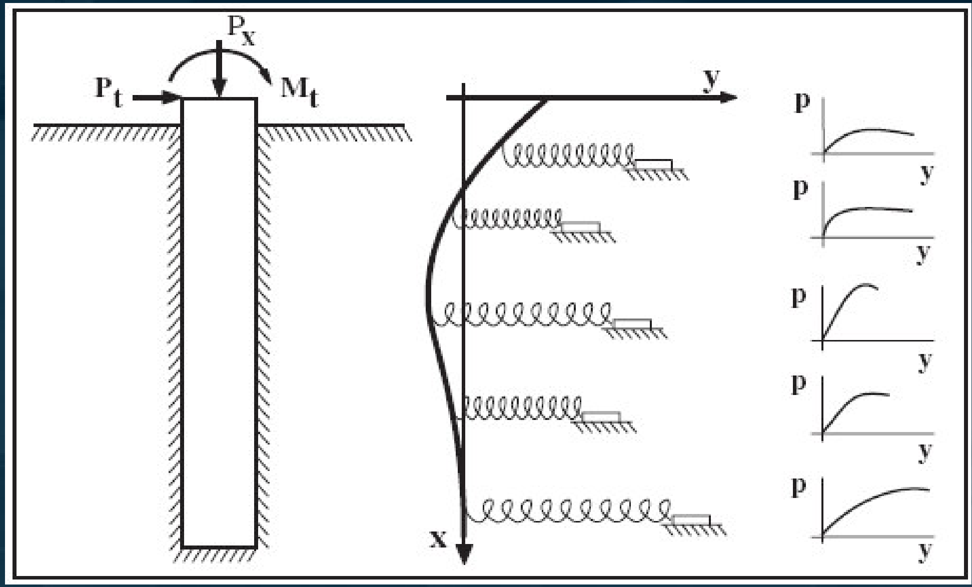
- Calculate vertical loads in piles using engineering judgment.
  - Assume equal distribution
  - Model cap as a continuous beam
  - Other…..
- Additional Loading
  - Moments caused by eccentricities of loads applied to the deck.
  - Forces, moments, and deflections caused by the construction sequence.
- Calculate the required thermal movement.
- Requires an assumed number of piles.

# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### Determine Soil Response:

- Soil response is a non-linear function of the pile deflection.
- One method of determining response is the P-Y Method.
- Geotechnical Engineer can assist in developing P-Y (soil resistance vs. pile deflection) curves.

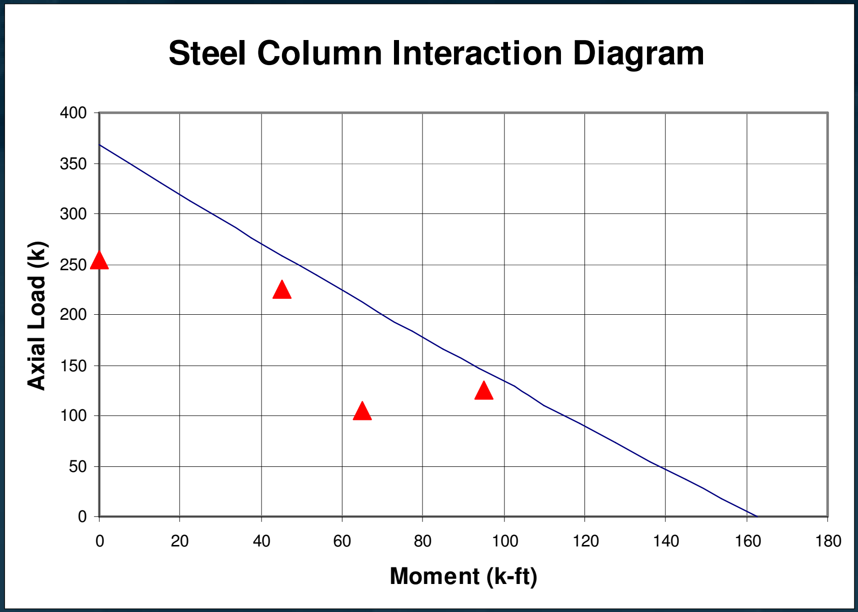


# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

Determine Pile Response:

- Develop deflected shape of pile under loading and determine POF.
- Develop interaction diagram for pile (plot of axial load vs. moment).
  - Use AASHTO column equations to determine the allowable envelope.
- Check pile loads for each AASHTO Loading Group against the interaction diagram.



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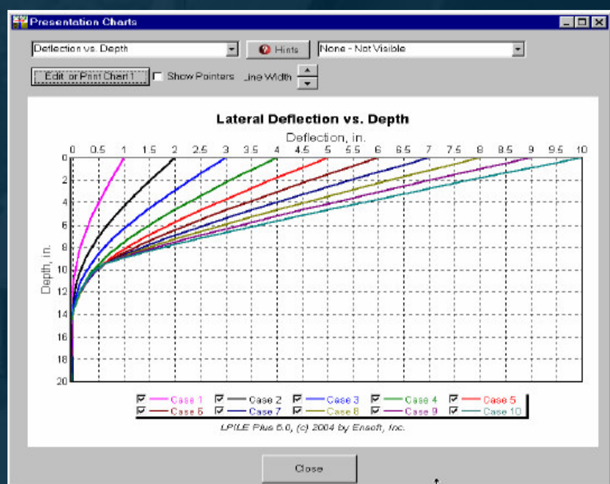
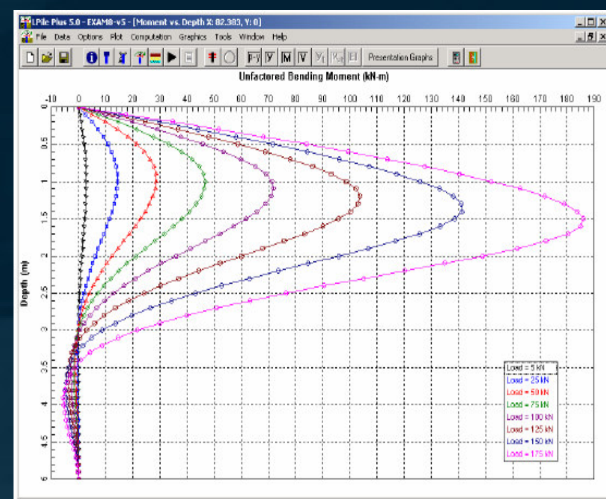
## 2. Simplified Analysis of Lateral Effects.

- Two software packages available are:
  - **LPile Plus** – developed and distributed by Ensoft, Inc. (www.ensoftinc.com)




  - **COM624P** – Report No. FHWA-5A-91-048
    Distributed by FHWA, McTrans, or PC-TRANS
(www.fhwa.dot.gov/engineering/geotech/software/softwaredetail.cfm)

# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### Summary:

- Models abutment separately from bridge superstructure.
- Requires that vertical and lateral pile loads be calculated along with expected thermal movement of cap.
- Soil response is obtained through P-Y curves.
- Resulting pile capacity is checked.
- Can require iteration between Geotechnical Engineer and Structural Engineer.

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# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

### General Approach:

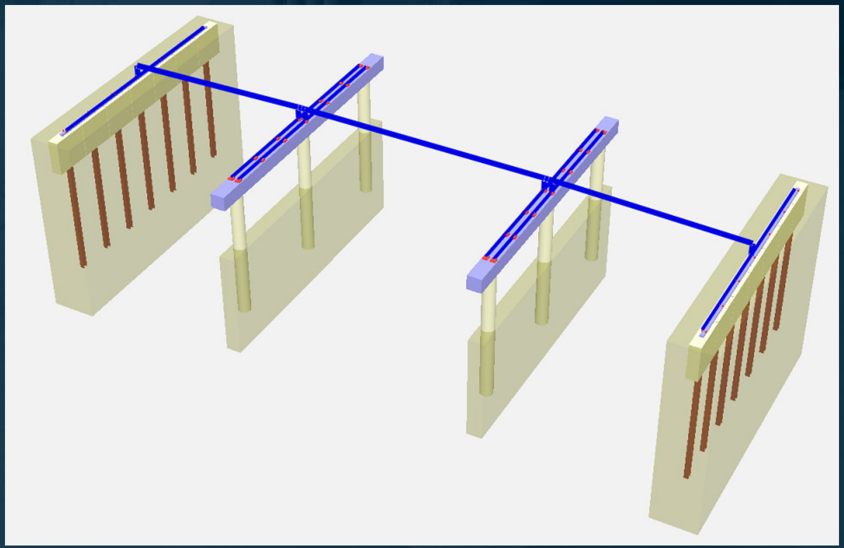
- Involves modeling the entire bridge (abutment to abutment) along with the foundation and soil in either 2-D or 3-D.
- Requires versatile FE program with soil interaction capabilities.
- Advantage is that it provides the Engineer a very detailed evaluation of the internal loads in each pile.
- Example approach is discussed in article by Christou, et al., titled "Soil Structure Analysis of Integral Abutment Bridges" (see reference no. 15 on provided list).

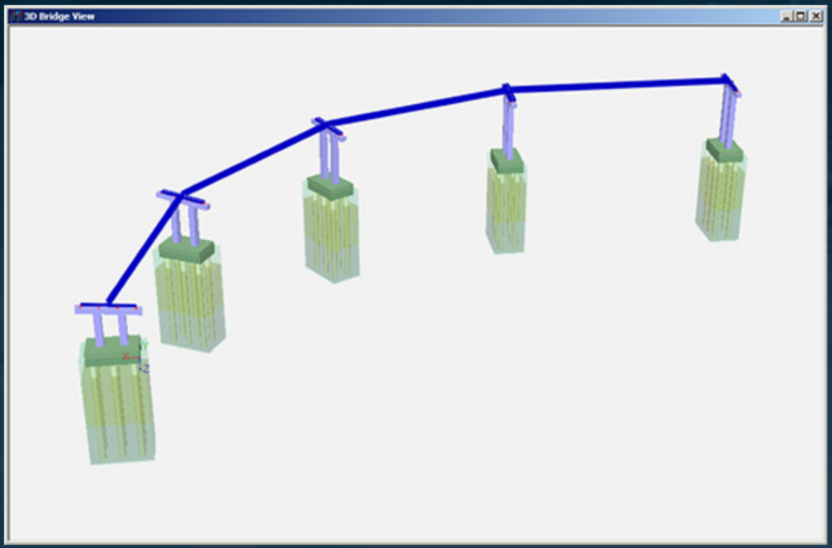
# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

Develop Model:

- Bridge is broken down into discrete elements.
- Superstructure can be simplified to a single line of 3-D elements.
- Abutments (caps, columns, and footings) are modeled as 3-D elements.



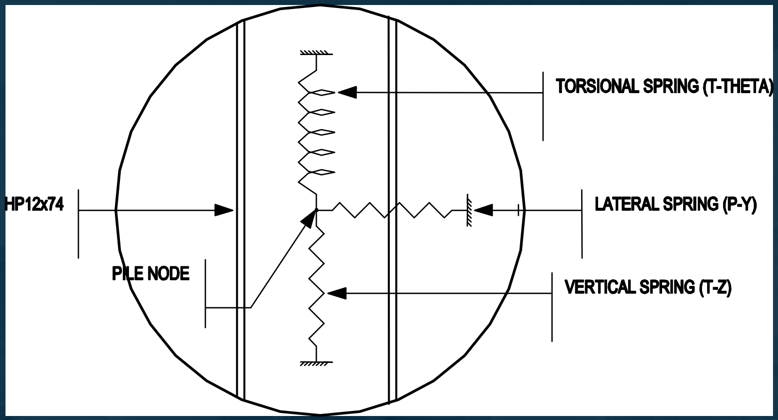


# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

### Develop Soil Response:

- Soil response is nonlinear and a function of the pile displacements.
- Soil is described by three sets of curve data:
  - P-Y Curve (lateral response)
  - T-Z Curve (vertical response)
  - Tau-Θ Curve (torsional response)
- Soil behavior is modeled by using multiple non-linear soil springs.
- Information obtained from Geotechnical Engineer.



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## 3. Rigorous Analysis of Lateral Effects.

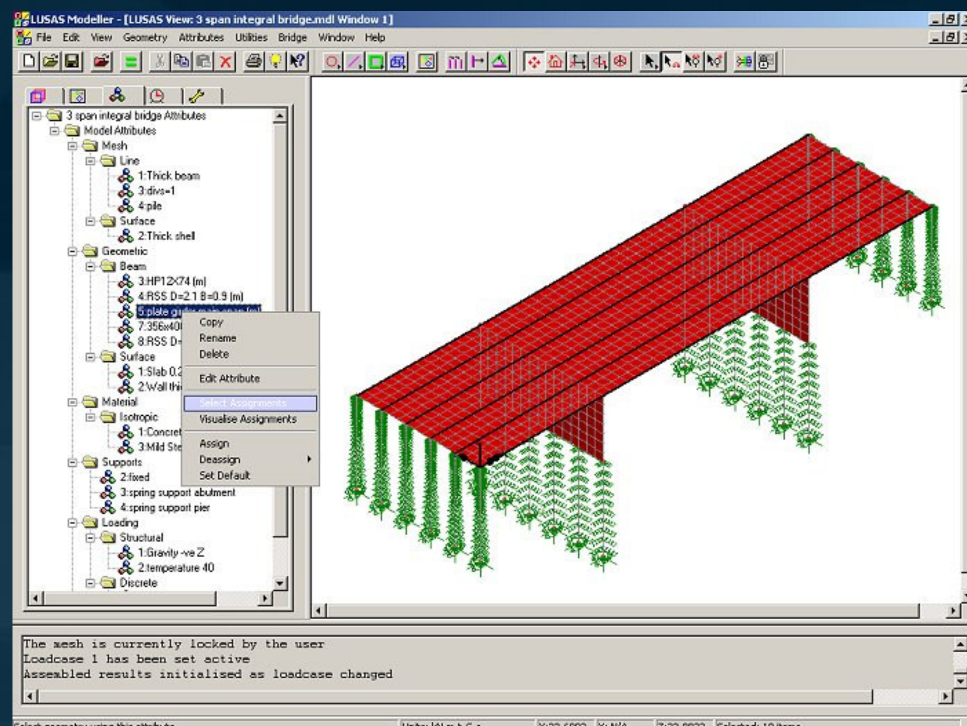
Process Output:

- Using program output, Engineer can easily evaluate the piles.
- Once model has been developed, and validated, alternative foundation types or layouts can easily be checked and optimized.

# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

- Two software packages available are:
  - **LUSAS Bridge Module** – developed specifically for modeling and analysis of jointless and integral abutment bridges. (www.lusas.com)



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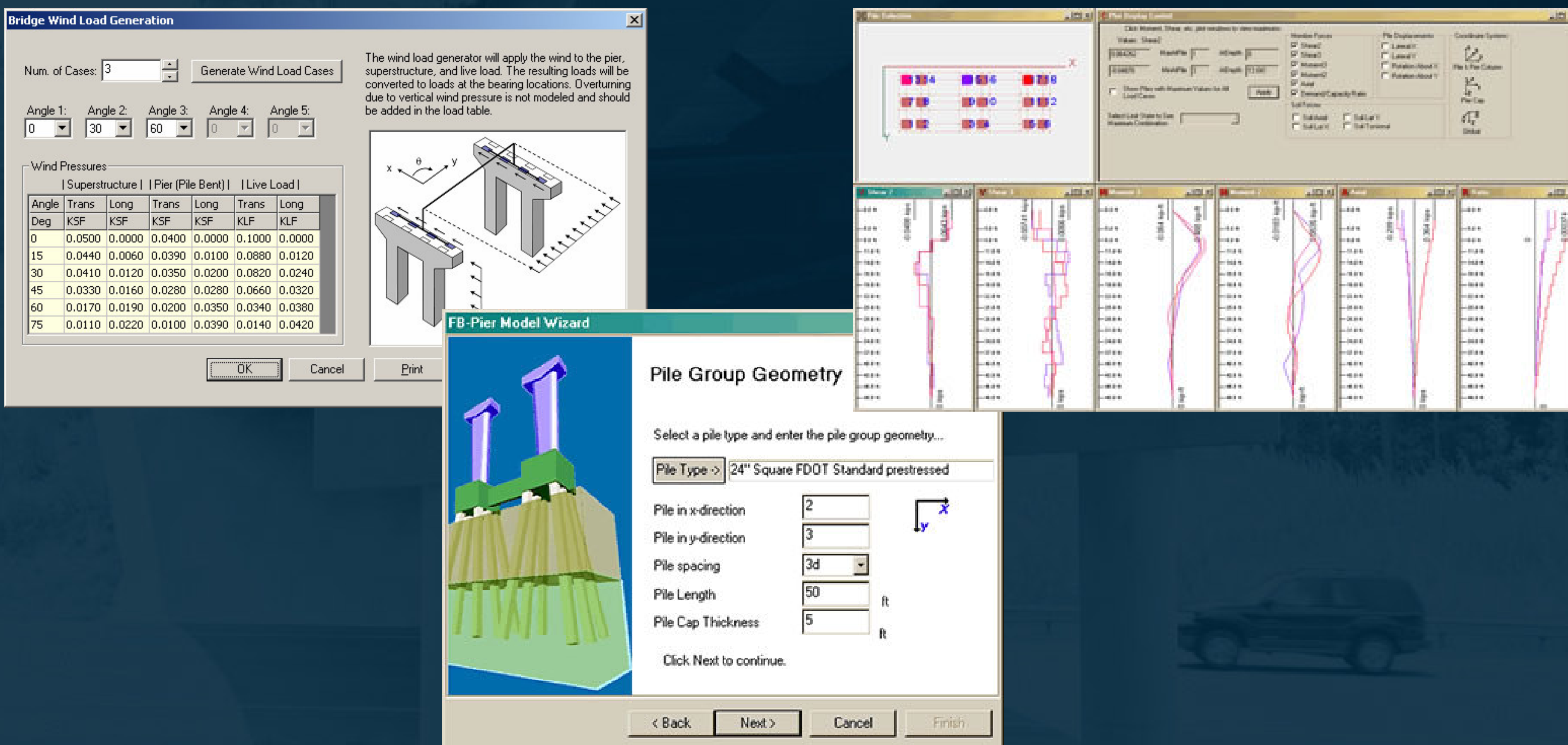
## 3. Rigorous Analysis of Lateral Effects.

- **FB-MultiPier** –nonlinear FE program capable of analyzing multiple pier bridges. (bsi-web.ce.ufl.edu)



# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

Summary:

- Method allows the Engineer to get the “Big Picture” view.
- Rigorous method can be complicated and time consuming.
- Beware of the “Black Box” syndrome (Garbage In → Garbage Out)

- Advantages:
  - Get a detailed quantitative evaluation of the internal loads in each pile.
  - Can easily run “what-if” type scenarios.
- Disadvantages:
  - Results are only as good as the soil response parameters.
  - Can generate large volumes of output.